RELIABILITY ASSESSMENT OF DISTRIBUTION SYSTEM AT PRESENCE OF DISTRIBUTED GENERATION

A thesis submitted in partial fulfillment of the requirement of the degree
B.Tech+M.Tech Dual Degree in Electrical Engineering

BY

Apurba Chandan Yadav
(710ee2073)

Department of Electrical Engineering

National Institute of Technology, Rourkela

India

May 2015

RELIABILITY ASSESSMENT OF DISTRIBUTION SYSTEM AT PRESENCE OF DISTRIBUTED GENERATION

A thesis submitted in partial fulfillment of the requirement of the degree
B.Tech+M.Tech Dual Degree in Electrical Engineering

SUBMITTED BY

Apurba Chandan Yadav
(710ee2073)

Under supervision of
Prof (Dr.) Sanjib Ganguly

Department of Electrical Engineering

National Institute of Technology, Rourkela

India

May 2015

CERTIFICATE

This is to certify that the project entitled, "**RELIABILITY ASSESSMENT OF DISTRIBUTION SYSTEM AT PRESENCE OF DISTRIBUTED GENERATION"** submitted by **Apurba Chandan Yadav (710ee2073)** is an authentic work followed up by him under my supervision and guidance for the partial fulfillment of the requirements for the award of **B.Tech+M.Tech Dual Degree** in **Electrical Engineering** at **National Institute of Technology, Rourkela (Deemed University).**

Prof (*Dr.*) Sanjib Ganguly

Dept. of Electrical Engineering,
National Institute of Technology,
Rourkela, India
Odisha-769008

ACKNOWLEDGEMENT

I express my gratitude and sincere thanks to my guide **Prof Sanjib Ganguly,** Department of Electrical Engineering, NIT Rourkela for his constant motivation and support during the course of my thesis. I am deeply indebted to him.

My earnest appreciation to the researchers, scientists and engineers whose years of toil have brought out the papers that have utilized in my project.

I am not only obliged to Samal sir but also thankful for his help and support.

I would like to thank my friends for their support. Finally I would like to thank my family.

Apurba Chandan Yadav

ABSTRACT

Reliability assessment plays a vital role regarding scheming of distribution systems. It ensures to operate in such an economical manner that the interruption at customer loads will minimum. No matter how the service from whether it’s an utility system (electric) or distributed system or any other types source, the main objective is to achieve the satisfactory reliability goal .Distributed generation (DG) importance is seen in this modern era power system network because using of various types of resources not only serves energy to power network but also conserve it too. DG is the backup option and its mere presences in the power system network effectively improve reliability of the system as it provides the support to the electrical power supply system. Dissimilar types of R Indices (Reliability Indices) can track frequency interruptions and period of customer interruption over a particular time range. Ultimate objective is to achieve the customer satisfaction. For that purpose proper planning should be execute. Here, the case analysis focusing on reliability analysis in the radial network system and evaluation of Reliability indices also impact of DG in the network system. The main objective is to improve the reliability of the system by putting DG to different buses. Simplified mathematical formulas are demoed. By analyzing the graphs a comparative conclusion is presented.

Contents

List of Figures

List of Abbreviations

DG	Distributed Generation
RI	Reliability Index
LP	Load Point
SAIFI	System average interruption frequency index
SAIDI	System average interruption duration index
CAIDI	Customer average interruption duration index
CAIFI	Customer avg interruption frequency index
AENS	Average expected energy not supplied
ENM	Equivalent network model
EES	Expected energy supplied

List of Tables

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Electric power networks are very convoluted. There are many reasons behind such structure of electrical system, size, disseminated geography; tie–in between the world cities hit it mostly. For uncontrollable nature, obscure behavior mainly reduced in efficient energy storing process. However Industrial firms are quite satisfactory with the evaluation of these complex structures. [1]

Power systems have evolved over decades. Their main motto is to provide power in reliable and economical manner to their consumers. There are certain criteria and procedure to overtake these problems. Basically these there are two aspects

- Deterministic
- Probabilistic

Reliability assessment is associated with availability of system, estimated undelivered energy, duration range of interruption etc.

1.2 ABSOLUTE AND RELATIVE MEASURES

For certain terms and condition applied for reliability indices measurements. These indices can be viewed from two angles-

- Absolute measures
- Relative measures

Absolute indices are the values that a system is expected to exhibit. They can be monitored in terms of past performance because full knowledge of them is known.
Relative indices are very easier way to interpret and considerable more confidence.

1.3 POWER SYSTEM ANALYSIS OF RELIBILITY

Reliability is associated with two terms. A) Adequacy b) Security

The first one related to the presence of ample facilities within the electrical system to satisfy the costumer load demand.

Capability of the electrical systems to respond the instantaneous disturbances arising within in it.

Power system of reliability generally involved with 3 major components

- Generating capacity reliability
- Distribution system reliability
- Composite system reliability

The composite zone is very complex because it included both the both generation and transmission system.

The below there is brief analysis is given on the above three system, how they all are involved in a power system network.

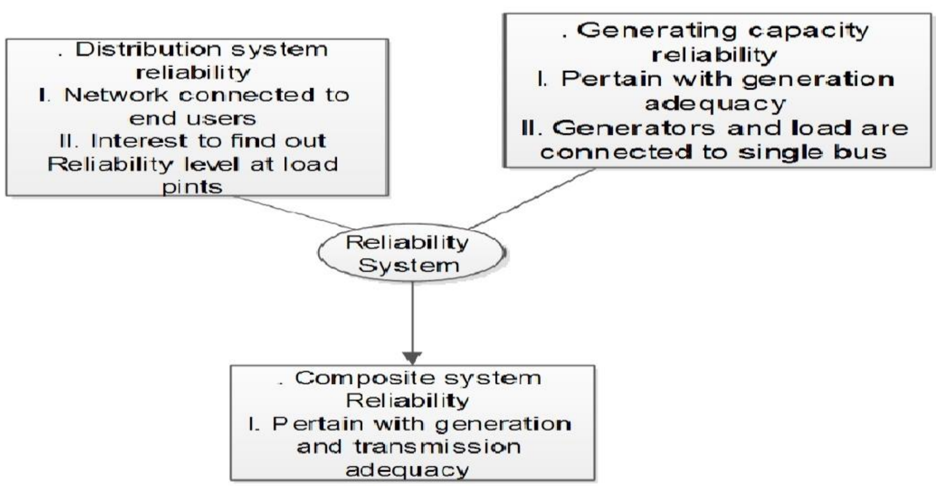


Fig 1.1

Reliability structure

1.4 RELIABILITY COST CURVE

Reliability and economics play a major integrated role in the decision-making process. This process comes under engineering system. Another major factor is that how investment cost is responsible for improving the reliability of the system.

Significance of cost curve

- These curves show that the investment cost generally increases with higher reliability
- The customer costs associated with failures decrease as the reliability increases
- When optimum value of cost is achieved then the reliability of system is improved

The cost curve is given below

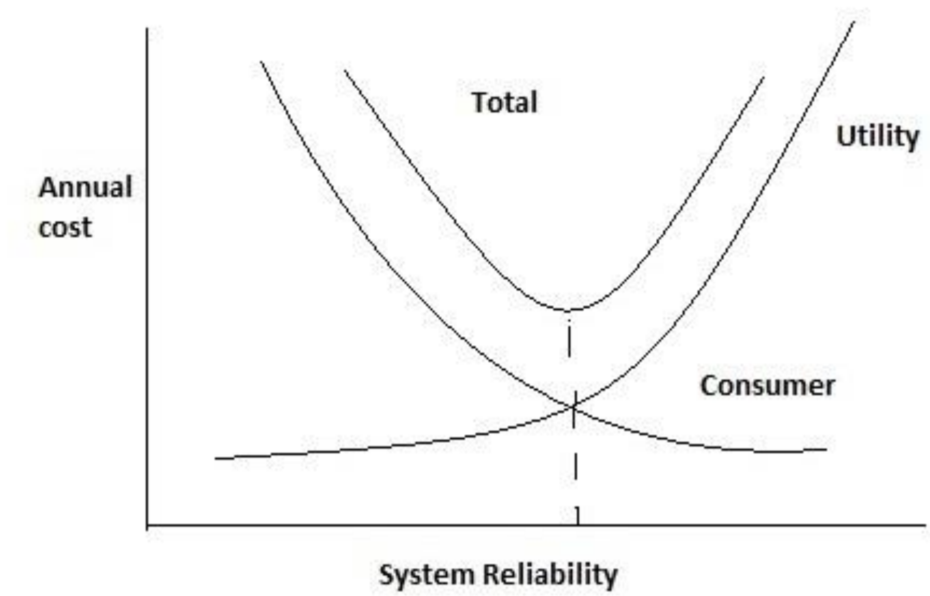


Fig 1.2

(Cost curve)

1.5 OBJECTIVE OF PROJECT

- To study the distribution network and reliability assessment in power system.
- Perform case study analysis in a radial net work
- Find the reliability indices and reliability evaluation technique
- Find R Index with and without the presence of DG in a radial network
- Reliability Modelling of distribution generation system
- Impact of DG in distribution system
- Reliability improvement in distribution system

1.6 LITERATURE REVIEW

Basically distributed generations (DGs) are renewable energy type as far as smart grid is concern. They are widely. Normally, distributed generation is defined as generation located in transformer substation, distribution feeder or customer, and whose capacity is less than 10MW.[1][3][11] These resources have much advantage such as friendly with external conditions or surroundings, very economical and highly flexibility, also structure is different than the traditional distributed system. Even though great amount of positive aspects they also brought some uncertainties to the network system.

Reliability of a system is cramped when that electrical system fails to provides power to consumers. These failures are named as outages or interruptions. There are factors that contribute to interruptions are life cycle of equipment and its maintenance, natural disasters like storms, quake, lightning etc. [16]

There is various methods for reliability evaluations. Analytical and simulation methods are common practices for evaluating reliability of a system. The first technique or the analytical method projected a mathematical model; this model generally computed the R index values.

Stochastic process concern with random behavior of the system. This method basically for finding probability of system and observes the system behaviors and counted it. No technique can give hundred percentage solutions, there are also some demerits. [1][13]

Both analytical technique and stochastic Monte Carlo Simulation (MCS) technique are used for reliability evaluation. The placement of DG at different load points and finding the best location the best location of a DG improves the reliability.[14][1][11]

The placement of DG in stand-alone or power grid connected network has huge advantage. Both the cases it makes the system more reliable. In first case it restores power during failure time. Grid connected case it not only provides the voltage support but also ease the overloading condition.[2][15]

CHAPTER 2

RELIABILITY INDEX ANALYSIS

2.1RELIABILITY

The term reliability has many aspects with respect to engineering system & economics. But when power distribution network is considered it refers to the continuity of power flow. It supplies continuous power to the customers. It provides power in such manner that the system behavior carrying on without interruption. The availability of power is nearly cent percent. If the system suffered from electric power then it’s under the zone of unreliability.

Reliability of a power system refers to the probability of its satisfactory operation over the long run. It denotes the ability to supply adequate electric service on a nearly continuous basis, with few interruptions over an extended time period.

There are certain conditions involved in power system network. Main objective is to provide power to customer points and should be focused on the customers desired amount with a particular time or intended time range. This synchronism process from the starting point to the end point implies a reliable system in electrical system. so In general talking about reliability is not a looking at a single direction, various aspects of the network should be judged and then to clarify whether system is reliable or not .This includes both technical and economic aspects

2.2 RELIABILITY INDICES

It is very important deal meaningfully with reliability for design of distribution network and also necessary to measure it and project goals. A foxing range of R Indices are used in the power industry. Some measure only frequency interruption and others only duration. A few try to combine both frequency and duration into a single value, which proves to be a very difficult task.

Basically two types of system

- System oriented
- Customer oriented

In the first one it is very broad meaning that it's looking at reliability over the whole customers. The second one is only focusing on the equipment or the customer only very complicated is that most utilities are evaluated multiple R Index.

The tough problem is that reliability measurement and how to relate the two quantity frequency and duration. The variation off these quantities from one to another customer is quiet awful. Duration is a very important factor. Even there are few minutes interruption can cause very huge losses. There are other customers in the industry short range outages causes no significant problem.

In the current scenario frequency interruptions has taken an important place in the electric power market. Very complex structure in the network responsible for it. Previously utilities perform very minor maintenance and operations to sort out problem for customers. Now it's very difficult because of the digital system.

The amount of power interrupted is also an important factor. Some of R Indices are weighted proportionaly to consumer at that time.

Four major reliability indices used for reliability analysis and they treat each and every customers in a system equally regardless of many factors like class, demand and energy sales. These indices are

- SAIFI
- CAIFI
- SAIDI
- CAIDI

The first and second measure frequency and the lowers measure duration. These four are make a vital conjunction and give information about a reliability system.

Above indices and some others are based on analysis of consumers during reporting period. Every single customer interruption is counted. Suppose one particular customer is interrupted five in a single year that constitute a five consumer interruption.

System Average Interruption Frequency Index (SAIFI) –

It is the net avg. number of interruption per customer during the period of analysis

Customer Average Interruption Frequency Index (CAIFI)-

It is the net avg. number of interruption suffered by the customer during the period of analysis that faced at least one interruption

$$\text{SAIFI} = \frac{Number\ of\ customer\ interruptions}{Total\ number\ of\ customer\ in\ system} \quad \text{-----------------} \ (1)$$

CAIFI= $\frac{Number\ of\ customer\ interruptions}{Total\ number\ of\ customer\ in\ system\ who\ had\ at\ least\ one\ interrupt.}$ -------- (2)

System Average Interruption Duration Index (SAIDI) –

It is the net avg. duration of interruption, obtained by averaging over all of the utility customers

Customer Average Interruption Frequency Index (CAIFI)-

It is the net avg. duration of interruption but avg only over the number of utility customers who had at least one outage.

SAIDI = $\frac{Total\ sum\ of\ durations\ of\ all\ customer\ interruptions}{Total\ number\ of\ customer\ in\ system}$ ---------- (3)

CAIFI= $\frac{Sum\ of\ durations\ of\ all\ ccustomer\ interruption}{Total\ number\ of\ customer\ in\ system\ who\ had\ at\ least\ one\ interrupt.}$ -------- (4)

In SAIFI the term S basically means the interruption statistics over the entire consumer system. The term C implies in CAIFI the customer those who are affected by these interruptions.

SAIFI & SAIDI are the feeder values. The values of these quantities are same for all the respective feeders. The defined term duration & frequency of interruptions means to the small group of customers.

2.3 RELIABILITY INDEX FORMULAS

Reliability Index (R Index)

EQN-a

System average interruption frequency index

$$SAIFI=\frac{\sum \lambda sysi\ Ni}{\sum Ni} = \frac{Total\ number\ of\ ccustomers\ interrpt.}{Total\ number\ of\ customer\ served}$$

EQN-b

System average interruption duration index

$$SAIDI=\frac{\sum Usysi\ Ni}{\sum Ni} = \frac{Sum\ of\ customers\ interrpt.duration}{Total\ number\ of\ customer\ served}$$

EQN-c

Customer average interruption duration index

$$CAIDI=\frac{\sum Usysi\ Ni}{\sum Ni\ \lambda sysi} = \frac{Sum\ of\ customers\ interrpt.duration}{Total\ number\ of\ customer\ interrupt.}$$

EQN-d

Average energy not supplied index

$$AENS=\frac{\sum Li\ Usysi}{\sum Ni} = \frac{Total\ energy\ not\ supplied}{Total\ number\ of\ customer\ served}$$

EQN-e

Average service availability Index

$$ASAI=\frac{\sum Ni*8760-\sum NiUsysi}{\sum Ni*8760} = \frac{Customer\ hours\ of\ available\ service}{customer\ hours\ demanded}$$

CHAPTER 3

Reliability Modeling

3. Schematic diagram

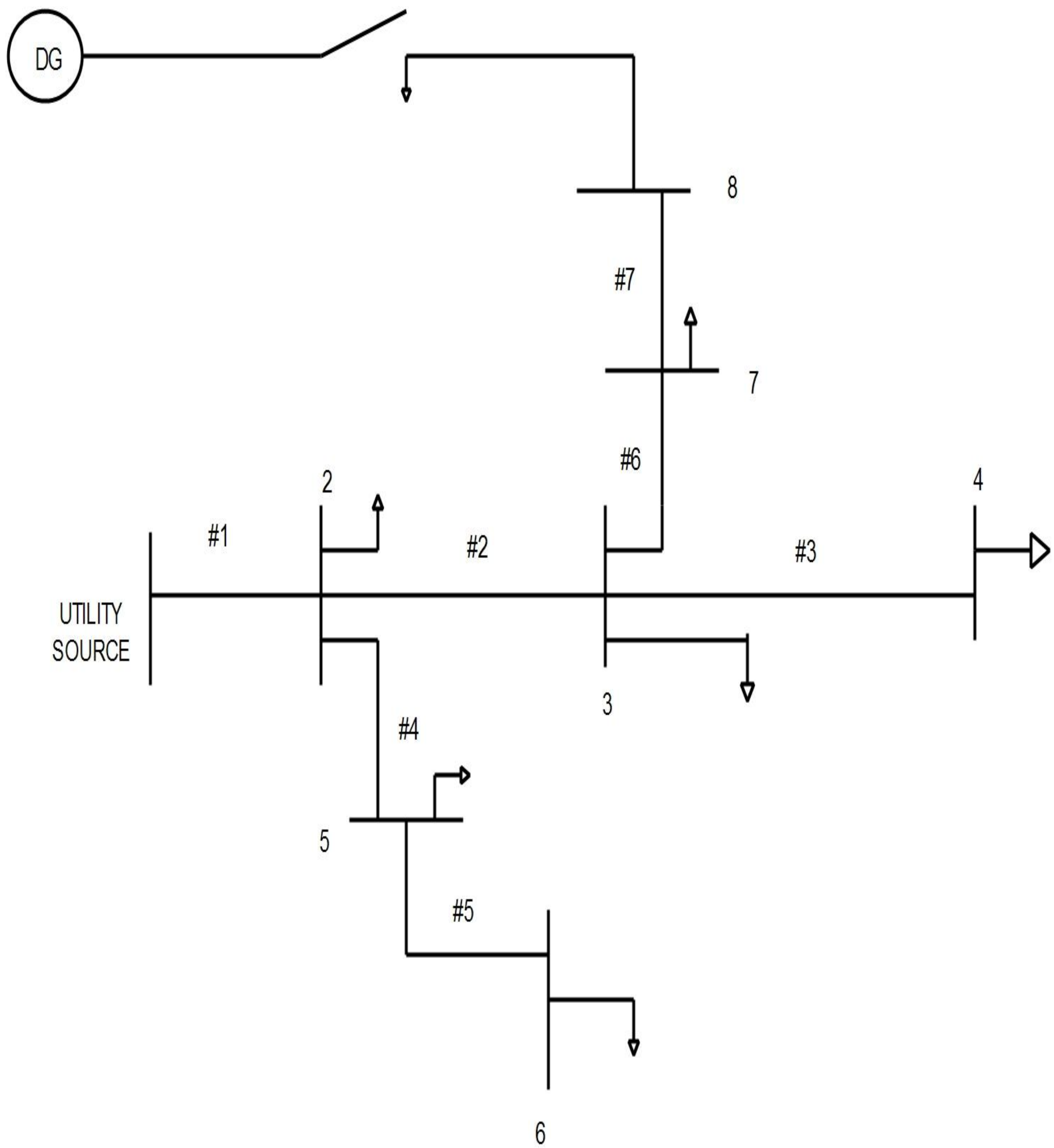


Fig-3.1

Eight bus radial network system

In the above diagram an eight bus system is given. The system is split into different sub divisional parts.

3.2 RELIABILITY ANALYSIS WITHOUT PRESENCE OF DG

When DG is not connected to any of the buses the equations are follows

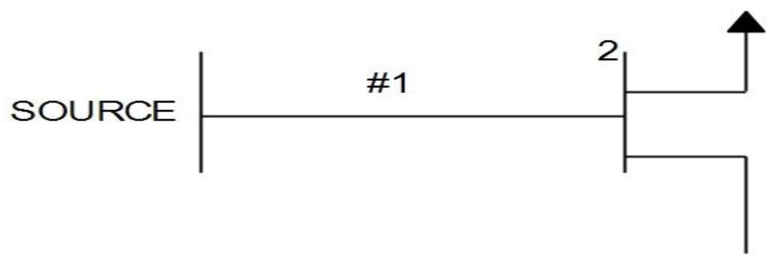


Fig-3.2

(LP2 without DG)

When DG is not connected to load point 2

$\lambda_{system,2} = \lambda_1$

$r_{system,2} = r_1$

$U_{system,2} = \lambda_1 r_1$--(3.1)

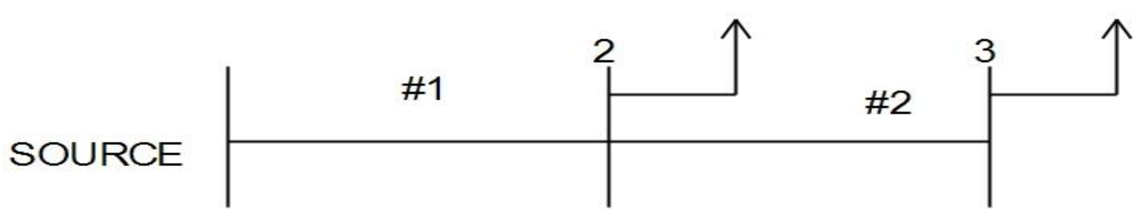


Fig-3.3
(LP3 without DG)

When DG is not connected to any of the load point

At load point 3(LP3) the R Indices can be calculated as

$\lambda_{sys,3} = \lambda_1 + \lambda_2$

$U_{sys,3} = \lambda_1 r_1 + \lambda_2 r_2$ ---(3.2)

$r_{sys,3} = u_{sys,3} / \lambda_{sys3}$

The above system the indices can be calculated as from EQN-a (R Index)

$$\text{SAIFI} = \frac{\lambda_1 N_1 + (\lambda_1 + \lambda_1) N_2}{N_1 + N_2} \text{-- (3.3)}$$

$$\text{SAIDI} = \frac{\lambda_1 r_1 \ N_1 + (\lambda_1 r_2 + \lambda_2 r_1) N_2}{N_1 + N_2} \text{-- (3.4)}$$

$$\text{CAIDI} = \frac{\lambda_1 r_1 \ N_1 + (\lambda_1 r_2 + \lambda_2 r_1) N_2}{\lambda_1 N_1 + (\lambda_1 + \lambda_2) N_2} \text{--(3.5)}$$

$$\text{AENS} = \frac{\lambda_1 r_1 \ N_1 + (\lambda_1 r_2 + \lambda_2 r_1) N_2}{N_1 + N_2} \text{-- (3.6)}$$

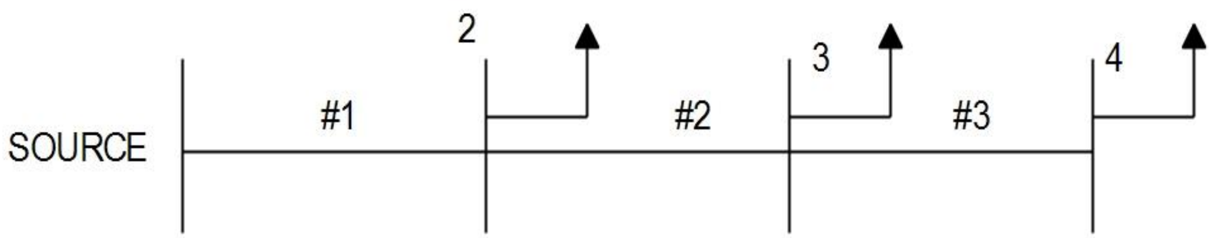


Fig-3.4

The above figure – R Indices at LP4

$\lambda_{sys,4} = \lambda_1 + \lambda_2 + \lambda_3$

$U_{sys,4} = \lambda_1 r_1 + \lambda_2 r_2 + \lambda_3 r_3$---(3.7)

$r_{sys,4} = u_{sys,4} / \lambda_{sys4}$

$$\text{SAIFI} = \frac{\lambda 1 N1 + (\lambda 2 + \lambda 1) N2 + (\lambda 2 + \lambda 1 + \lambda 3) N3}{N1 + N2 + N3} \text{ ---------------------------------- } (3.8)$$

$$\text{SAIDI} = \frac{\lambda 1 r1 N1 + (\lambda 1 r1 + \lambda 2 r2) N2 + (\lambda 1 r1 + \lambda 2 r2 + \lambda 3 r3) N3}{N1 + N2 + N3} \text{----------------- } (3.9)$$

Likewise the other indices are calculated from the equation 3.5 & 3.6.

For Load point 5 the Index

$$\lambda_{\text{sys},5} = \lambda_1 + \lambda_4$$

$$U_{sys,5} = \lambda_1 r_1 + \lambda_4 r_4$$

$$r_{sys,5} = u_{sys,5} / \lambda_{sys5}$$

For Load point 7

$$\lambda_{\text{sys},7} = \lambda_1 + \lambda_2 + \lambda_6$$

$$U_{sys,7} = \lambda_1 r_1 + \lambda_2 r_2 + \lambda_6 r_6$$

$$r_{sys,7} = u_{sys,7} / \lambda_{sys7}$$

For load point 8

$$\lambda_{\text{sys},8} = \lambda_1 + \lambda_2 + \lambda_6 + \lambda_7$$

$$U_{sys,8} = \lambda_1 r_1 + \lambda_2 r_2 + \lambda_6 r_6 + \lambda_7 r_7$$

$$r_{sys,8} = u_{sys,8} / \lambda_{sys8}$$

For load point 6

$$\lambda_{\text{sys},6} = \lambda_1 + \lambda_4 + \lambda_5$$

$$U_{sys,7=}\ \lambda_1 r_{1\ +}\ \lambda_4 r_4 + \lambda_5 r_5$$

$$r_{\ sys,6=}\ u_{sys,6} / \lambda_{sys6}$$

The rest of system Indices are calculated using the above mathematical formulas and putting the values in EQN abc we would find out the R Indices.

3.3 RELIABILITY ANALYSIS WITH PRESENCE OF DG

From the previous chapters Insertion of DG in an electrical network makes the system more reliable. When there is failure from main source supply DG provides power to the system so it act like a stand by unit

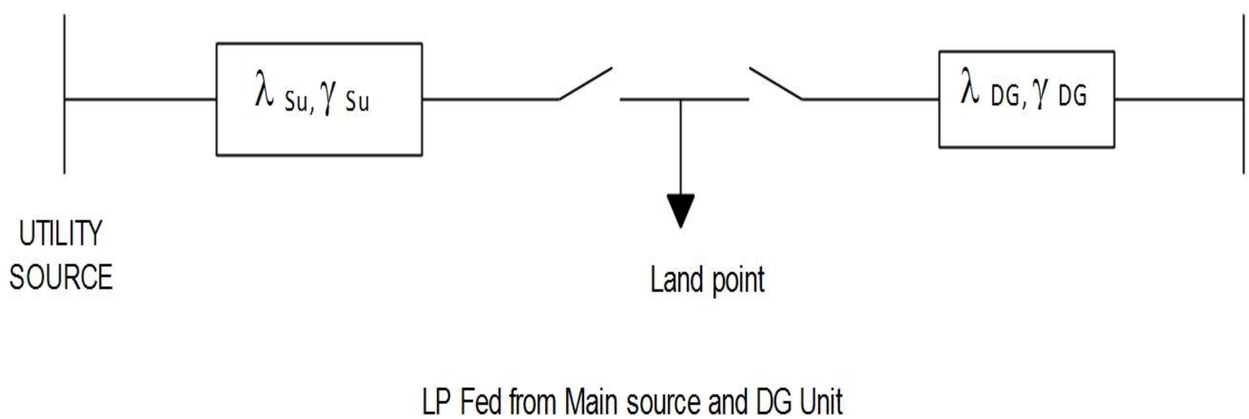


Fig 3.5

(LP Fed from DG and Main source)

λ_s = total failure rate

γ_s = total avg interruption duration

λ_{dg} = failure rate of DG

γ_{dg} = total avg outage duration (DG)

Addition of DG at each load point in the above fig-3.1 makes it a parallel system. The equivalent network of the system represented below

Fig-3.6

(Equivalent Model of DG connected Parallel Network)

λ_{EQ} = failure rate of equivalent network

r_{EQ} = total avg interruption duration of the network

The objective of the work is to insert DG at each load points and then find the R Indices. After addition of DG in a load points the system behaves as parallel network that can be model from the below equation

$\lambda_{PP} = \frac{\lambda_d \lambda_r \ (r_d + r_s)}{1 + r_d \lambda_d + r_s \lambda_s}$ ---(3.10)

$\frac{r_d r_{rs}}{r_d + r_s}$ --- (3.11)

$$U_{pp} = \lambda_{PP} * r_{pp}$$

λ_{PP} = failure rate of parallel network (with DG)

r_{pp} = avg interruption duration of the parallel network

From fig 3.1 the DG connected model is

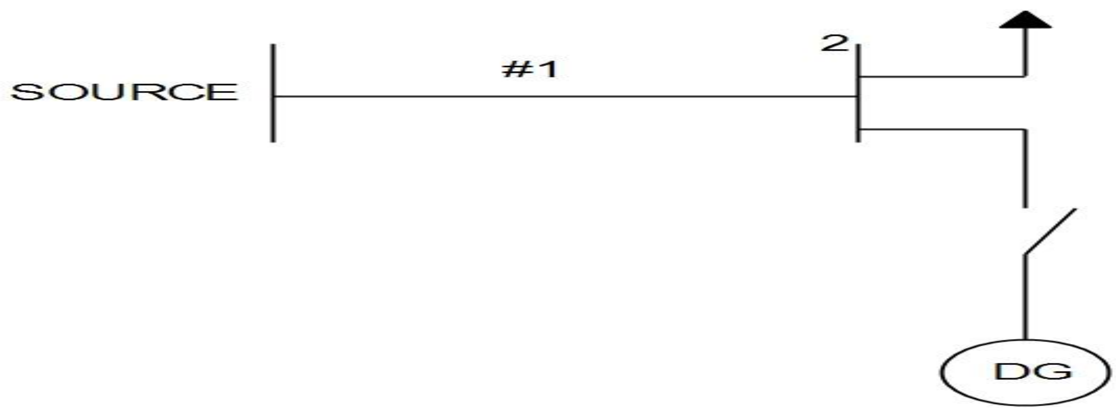


Fig 3.7

LP2 connected with DG

Occurrence of fault in the branch #1 leads to interruptions of power supply for the customers, so in order to supply continuous power to above network DG is connected make the system more reliable. Here the distributed generation applied at bus 2. From 3.10 & 3.11 we can calculate the R Index of the network.

$\lambda_{sys\ 2} = \lambda_{st2}$

$r_{sys\ 2} = s_2$ --(3.12)

S_2 is the restoration time

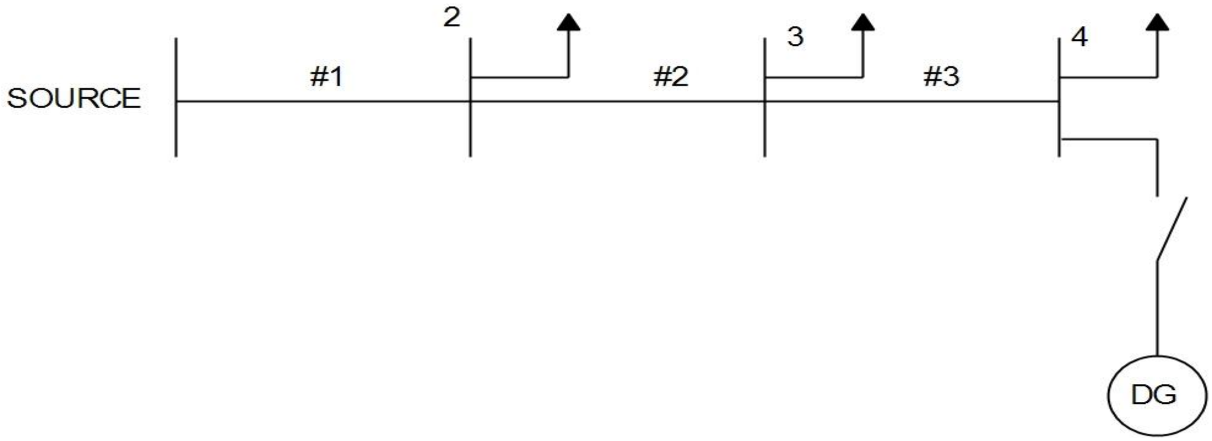


Fig 3.8

(LP4 is connected with DG)

Here DG is connected at LP 4. λ_{st} is the failure rate of the switch connected with DG and s is the restoration time.

From eqn 3.7 we can get the equation of λ_{sys} i.e.

$$\lambda_{sys,4} = \lambda_1 + \lambda_2 + \lambda_3$$

$$U_{sys,4} = \lambda_1 r_1 + \lambda_2 r_2 + \lambda_3 r_3$$

$$r_{sys,4} = u_{sys,4} / \lambda_{sys4}$$

To finding the R Index λ_{PP} is required so λ_s is replaced to λ_{sys} 4 and λ_d to λ_{st}
In this way putting these parameter in the expression (3.10-3.11) of λ_{PP} the Reliability Indices can be calculate.

CHAPTER 4

OUTCOMES

Results & Analysis

Graphs

Comparative Analysis

4.1 SYSTEM DATA

Table No-4.1

Radial Distribution Network Data

Distribution Section	λ_j^0 (1/yr)	r_j^0(1/yr)
1	0.40	10
2	0.20	9
3	0.30	12
4	0.50	20
5	0.20	15
6	0.10	8
7	0.12	12

Here the data given for the 8 bus radial distribution system. The failure rates of each section (distribution network) are given. DG is connected to each load points 2,3,4,5,6,7 & 8 and R indices of each load point are obtained.

Here the DG has sufficient capacity to fulfill demand of all customers connected at different load points. In the given data of table 4.1 the current values of failure rate (λ) and repair rate (r) are taken.

Table NO-4.2

Load Points & Customers Data

Load Points	Avg local load (kw)	No. of customer	No of Customer affet.
2	1000	200	100
3	700	150	50
4	400	100	40
5	500	150	50
6	300	100	40
7	200	250	100
8	150	50	20

The number of customers associated with the each load points and also the total load consumed at each points are given in the above table .When fault occurs the customers linked to the respective LP are affected. In the given system the network constitutes total seven load points.

In Chapter 3 there reliability modeling and mathematical analysis has given. A healthy analysis is given for reliability assessment in a distribution network with & without presence of DG.

By using those mathematical models the graphs and reliability indices are obtained.

4.2 RESULTS

Table No-4.3

Reliability Indices without presence of DG in Distribution network

Results							
R Index	LP_2	LP_3	LP_4	LP_5	LP_6	LP_7	LP_8
SAIFI	0.40	0.48	0.57	0.61	0.672	0.5	0.7
SAIDI	4	4.77	5.80	8.28	10.22	5.52	5.67
CAIDI	10	9.82	10.038	13.48	15.34	1.00	1.00
AENS	20	23.02	26.26	31.42	35.75	15.34	15.50
Λ_{SYS}	0.4	0.6	0.9	0.9	1.1	0.7	0.8
U_{sys}	4	5.8	9.40	14	17	6.60	7.4
r_{sys}	10	9.6	10.44	15.5	15.45	9.42	9.25

The R indices values are given in the above table. At Load point 6 the Avg expected not supplied is maximum. Due to use of the current values of the failure and repair rate the system avg. frequency index all values are less than one.

Table No-4.4

Reliability Indices with presence of DG in Distribution network

Results							
R Index	LP_2	LP_3	LP_4	LP_5	LP_6	LP_7	LP_8
SAIFI	0.44	0.41714	0.352	0.437	0.457	0.47414	0.56695
SAIDC	0.52	2.53201	3.851	2.571	6.5377	3.033	5.153
CAIDI	1.30	6.06990	8.963	5.879	11.14	6.397	9.04
AENS	2.405	12.49	18.36	12.237	20.20	13.55	14.50
λ_{SYS}	0.4	0.443	0.482	0.487	0.497	0.458	0.469
r_{SYS}	1.30	1.29	1.311	1.367	1.026	1.293	1.290

4.3 GRAPHS

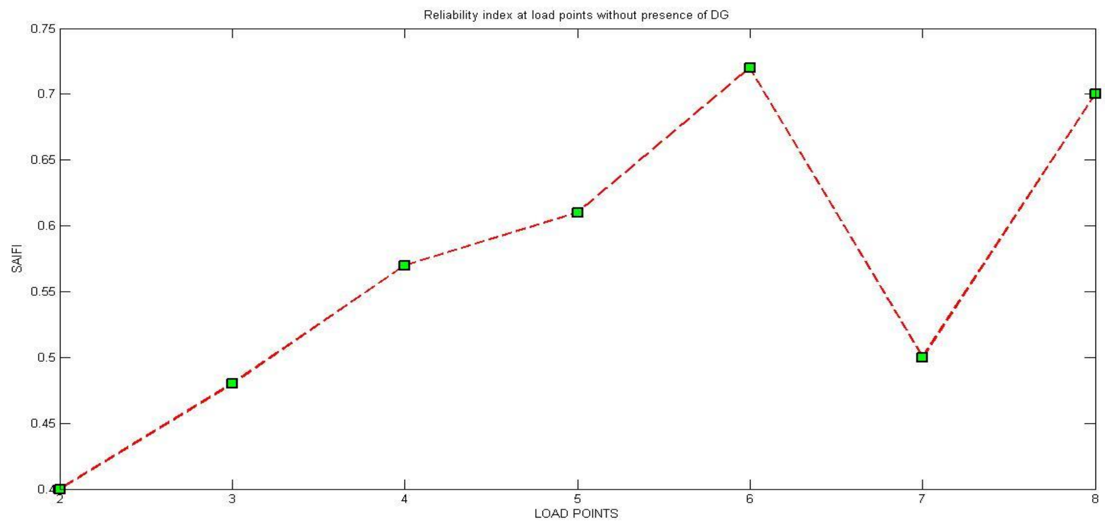


Fig No 4.1 SAIFI values at each LPs (without DGs)

In the above graph it signifies the values of SAIFI at each load point without presence of DG in 8 bus radial network shown in figure 3.1.In the below graph it is the value of SAIFI with presence of DG

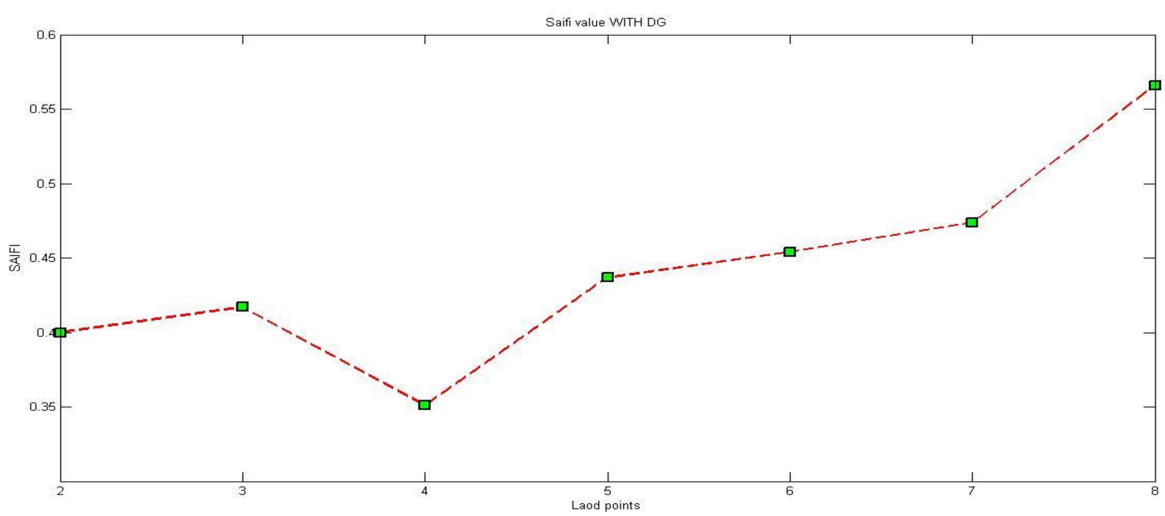


Fig No-4.2 SAIFI values at each LPs with DG

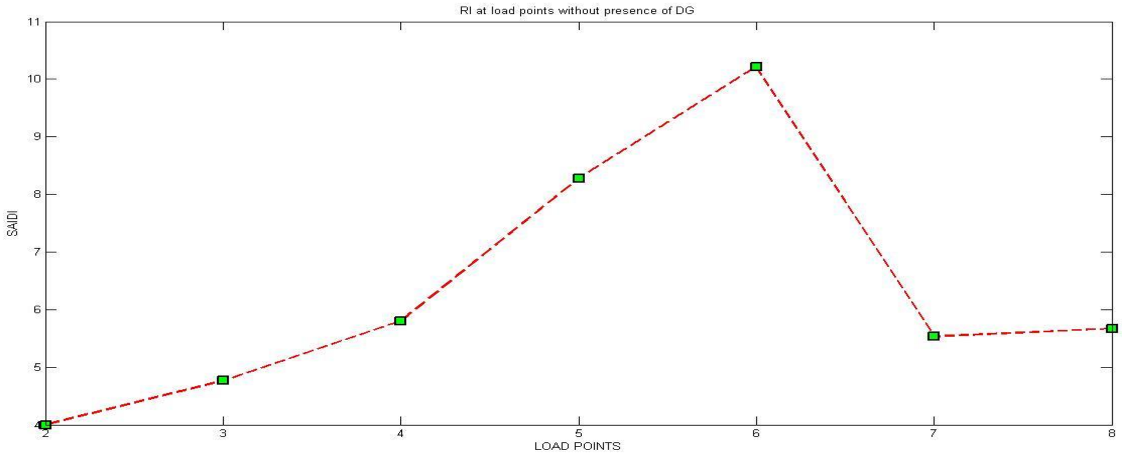


Fig No-4.3 SAIDI values at each load points without DG

In the above curve the values of SAIDI (without presence of DG) at each load points. The below it shows the SAIDI values (with presence of DG) at each load points.

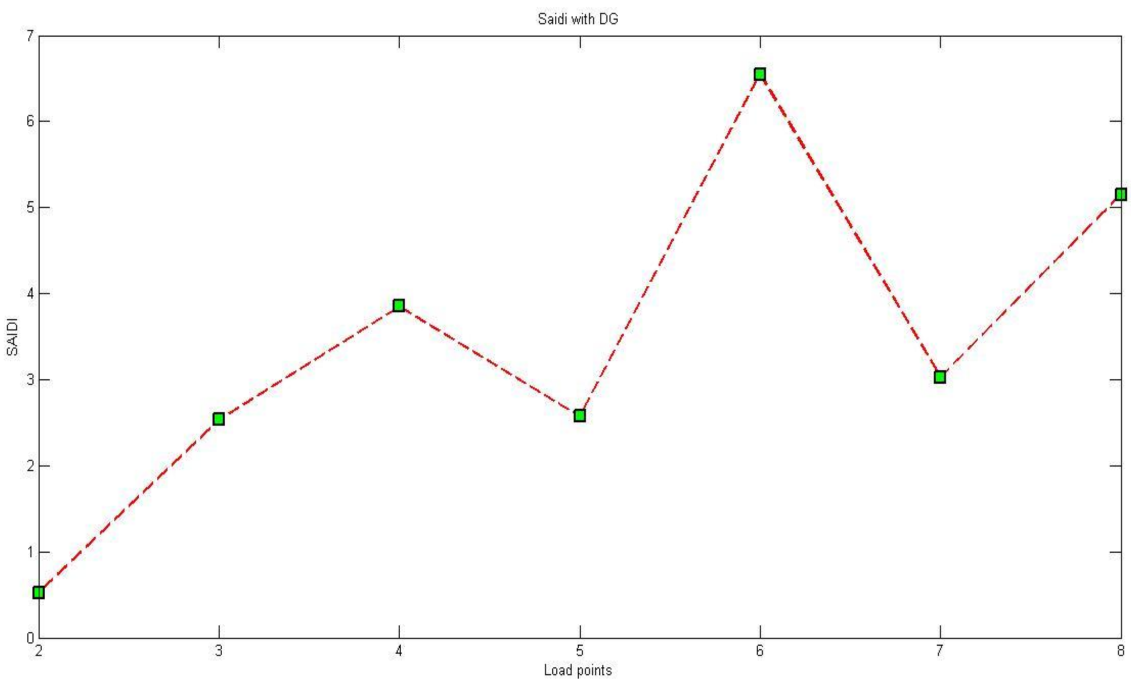
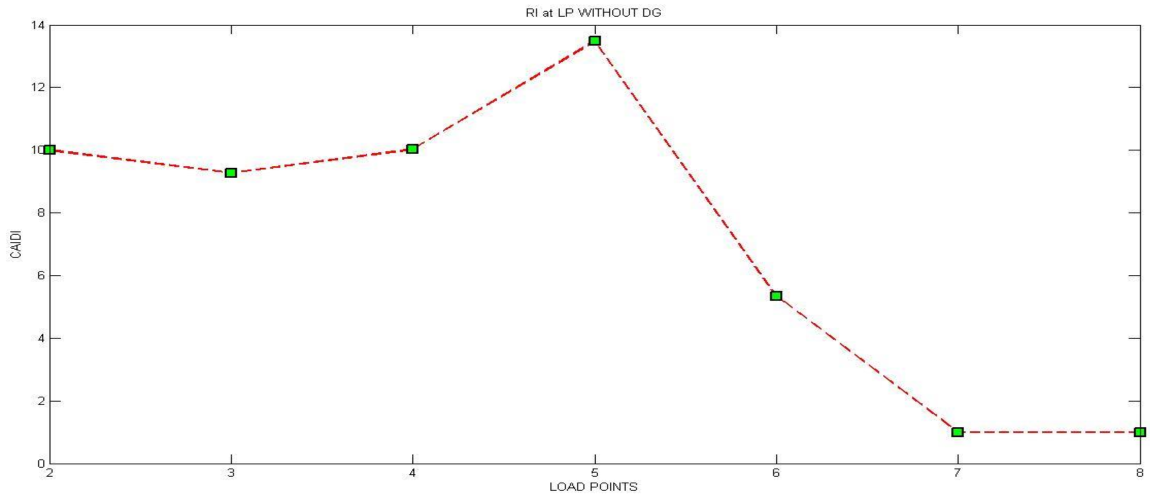


Fig No 4.4 SAIDI values at each load points with DG



The above graph CAIDI values (without presence of DG) at each load point.The below graph shows the CAIDI values(with DG) at each load points.

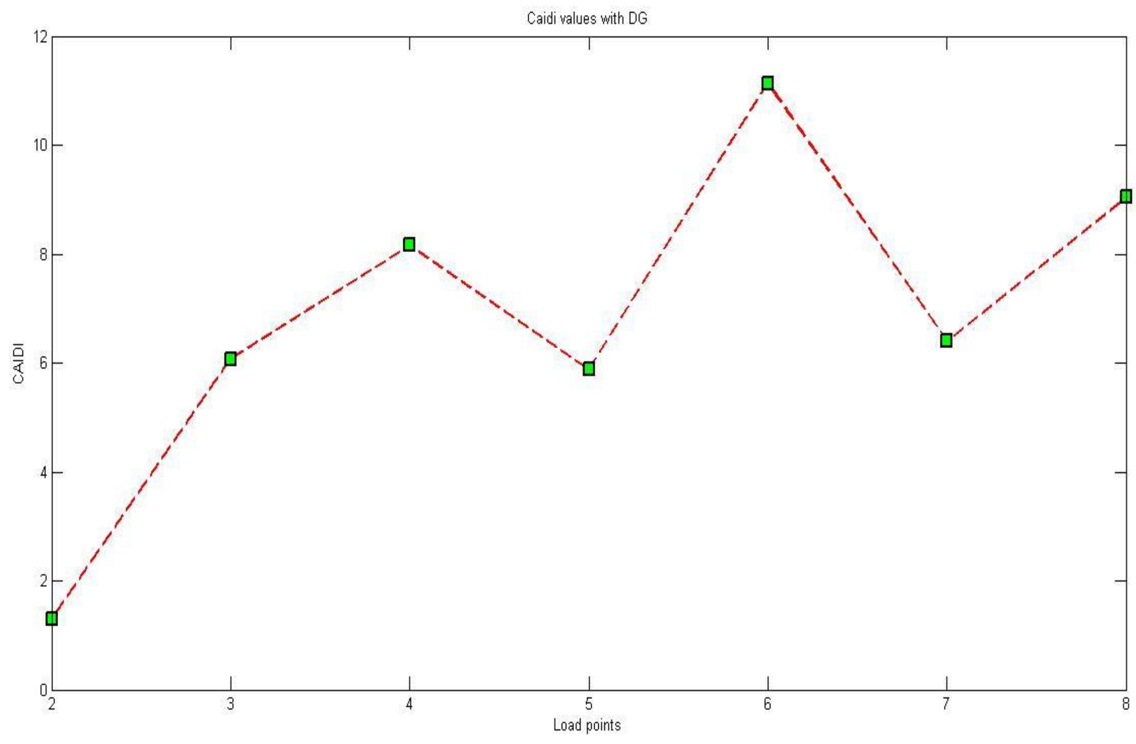
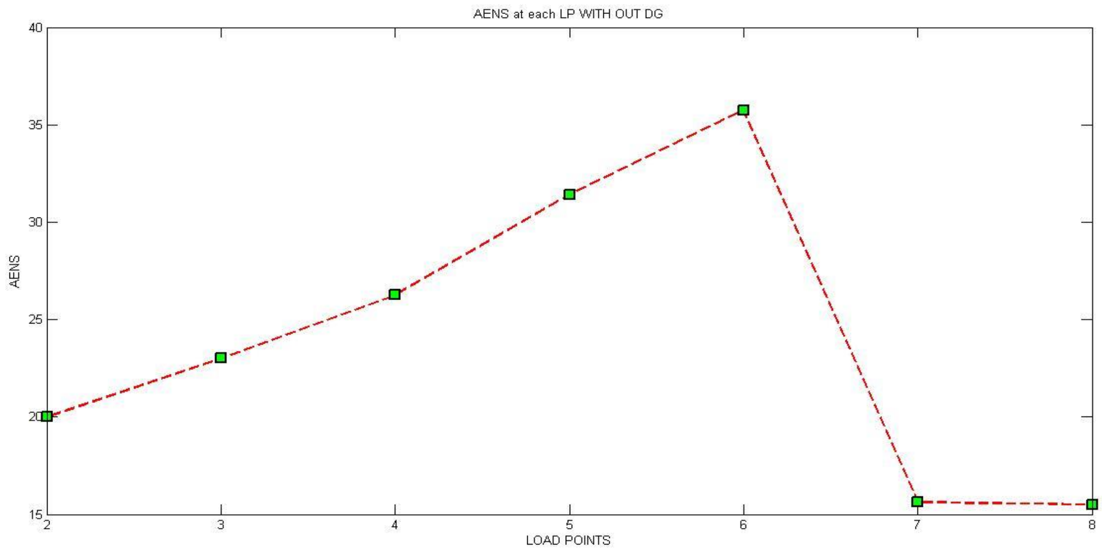


Fig No 4.5 & 4.6

CAIDI values at each LPs without and with presence of DG



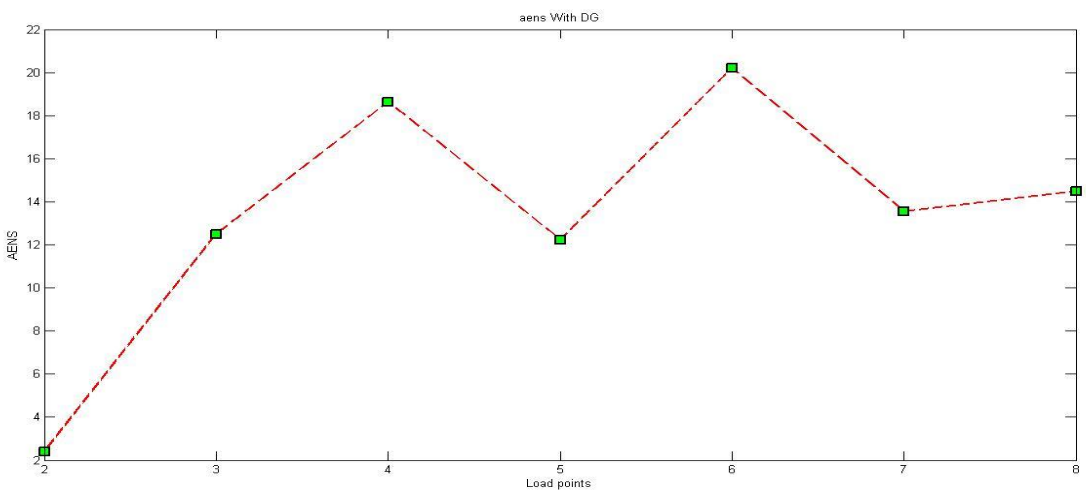


Fig No 4.7 & 4.8

AENS values at each LPs with and without presence of DG

The above graphs represent the Value of AENS at each load points without and with the presence of DG in the fig 3.1 given electrical network

4.4 COMPARATIVE ANALYSIS

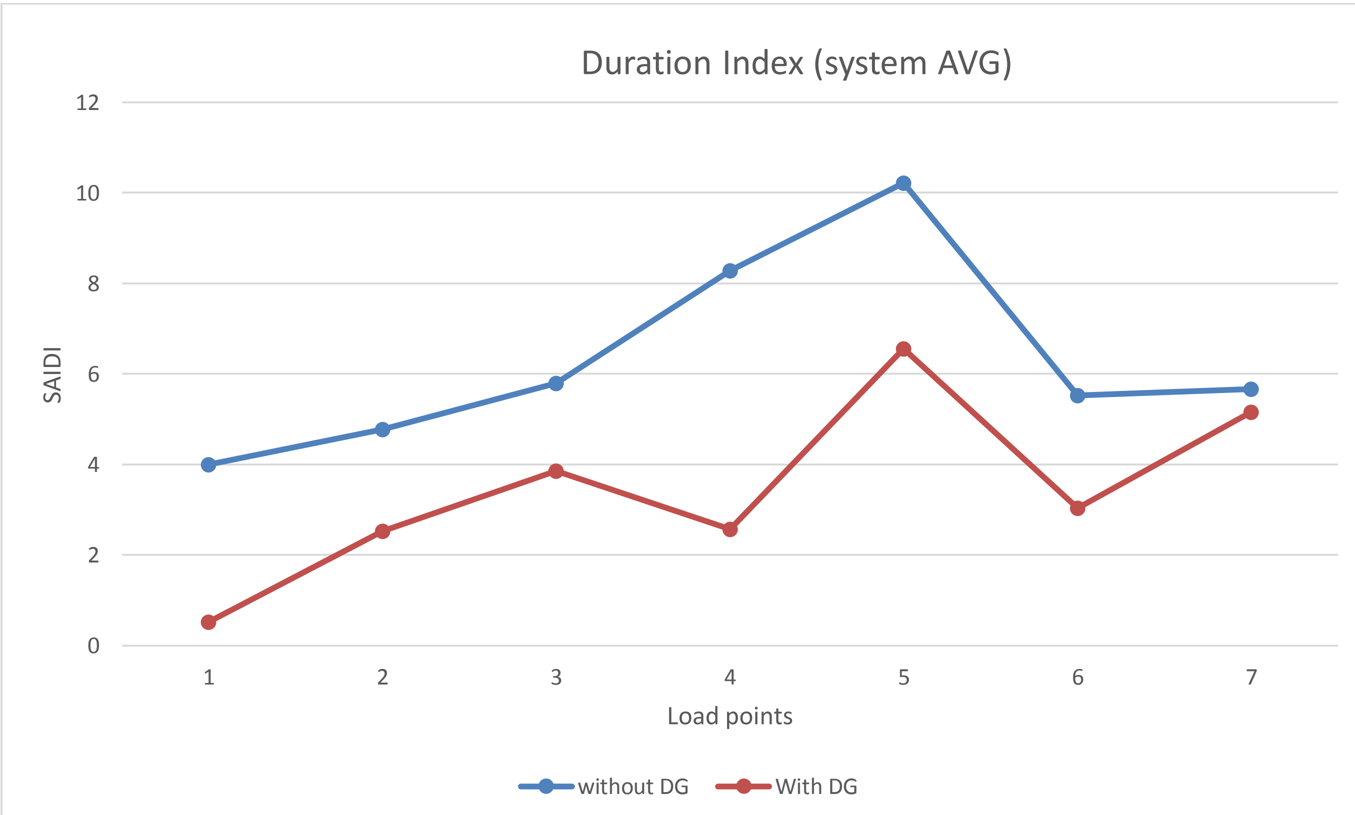


Fig No 4.9 (SAIDI COMP.)

The SAIDI values are given in the figure. From 1to 7 or load point 2 to LP 8 the values are decreasing after addition or insertion of DG at each point in the radial network.

This shows the increasing of system reliability and decreasing of R Index. Due to significant role of SAIDI regarding interruption the durability is decreased.

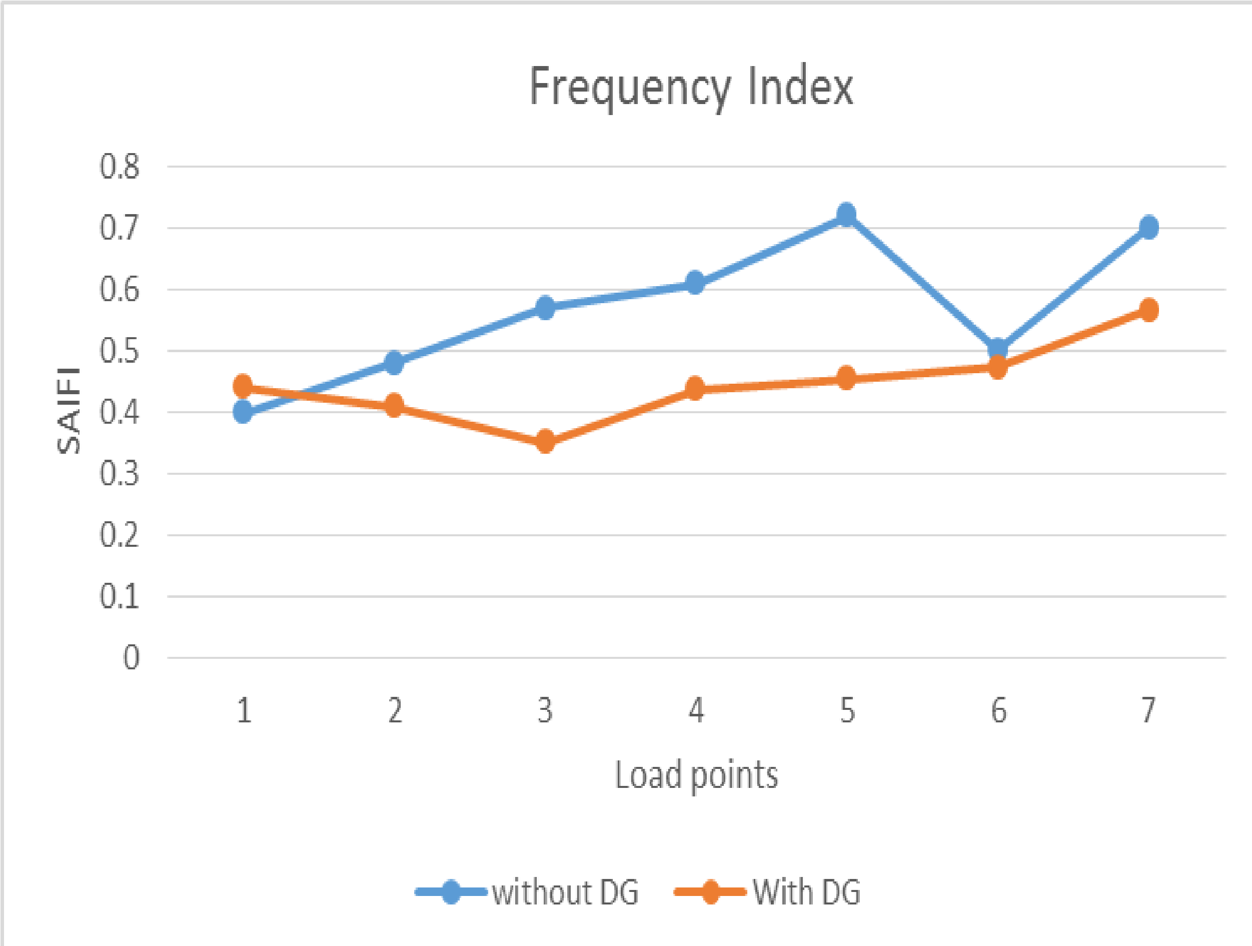


Fig no 4.10 (frequency curve)

As we know SAIFI is related to frequency Index, it measures only frequency in an electrical network. In the above curve signifies with the presence of DG in fig 3.1 at each load points the SAIFI is decreased. We obtained the minimum value at Load point 3. Absence of DG at LP5 point is highly unreliable to the customer at that point. There are very smooth transition between LP4 to LP6 that means frequency interruptions suffered by most of the customer is very modest. Initially some undesirable factors make the system bit gunky. It's clearly shows that whole reliability of distribution network is improved.

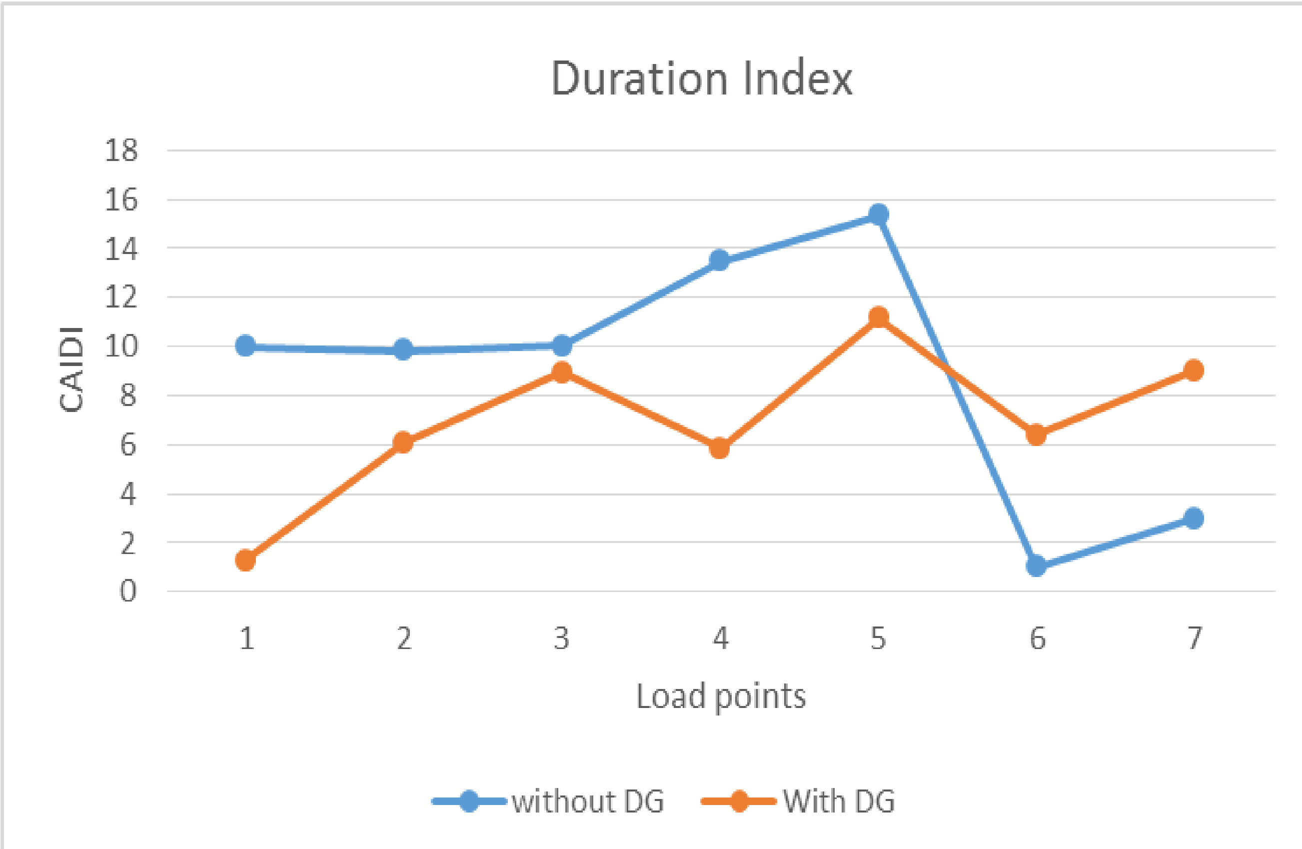


Fig No 4.11 (Duration index curve)

CAIDI value at 1 to 5 or LP1 to LP5 decreased .This comes under comfort zone of reliability. LP 5 has the most minimal value after connection a DG to all respective Load points. At point 6 and 7 duration index is increased that leads non-reliability this because at this point customer demand is not fulfilled by DG .Mostly the load consumed by the customers at that point is more. For 250 customers the local load is about 200kw, that's the main reason the CAIDI value increased in 6 and 7 points. Other than that the reliability assessment is improved at others LPs.

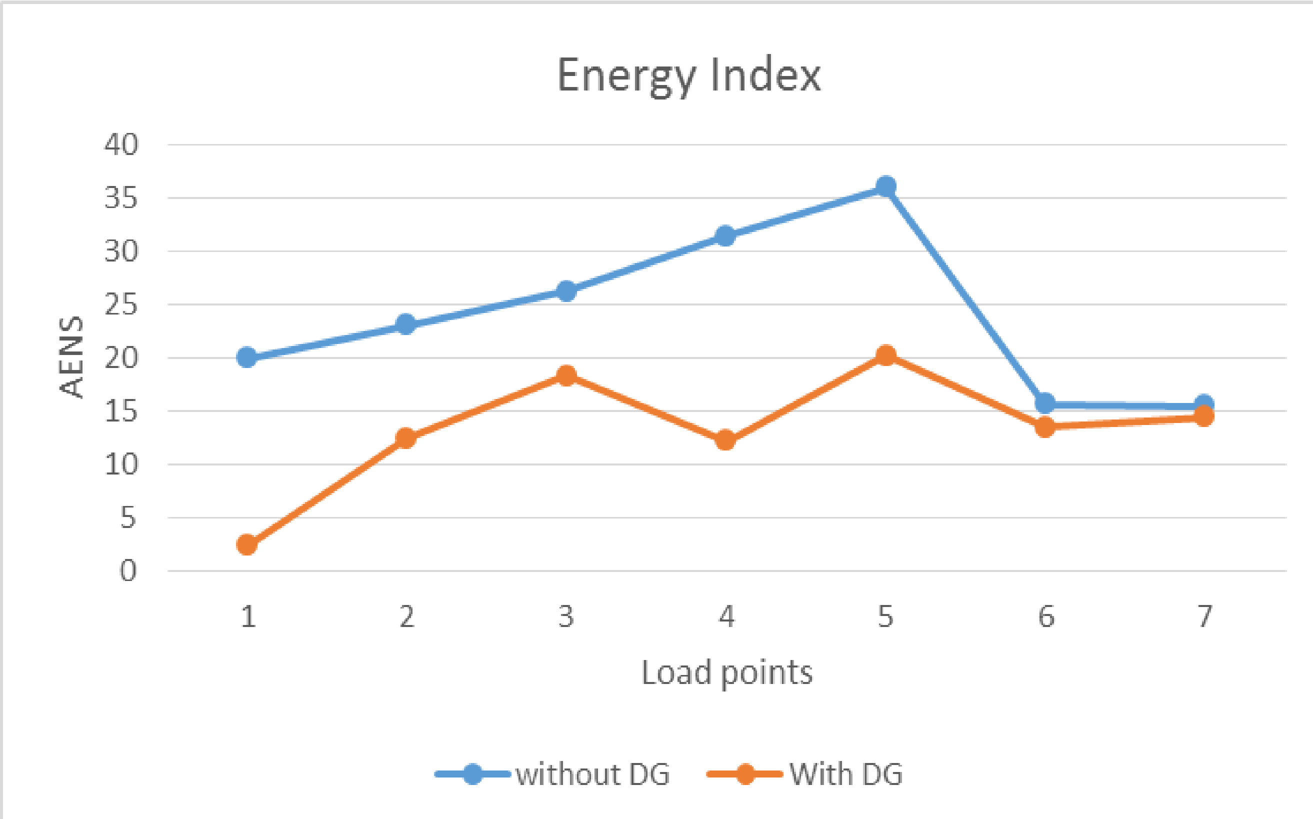


Fig No-4.12 (energy Index curve)

The above curve it's clearly shows that the average energy not supplied by the customer is decreased after DG is connected to system. The customers all most get the required energy. Considering at load point 4 the energy difference between with presence and absence of DG has maximum. So it could be considered as the best reliable network point. Addition of DG to each point make the overall system reliable, difference is that some of the load points customers get more energy some are gets less but comparatively the DG at LPs has achieved a significant value by diminishing the R Indices.

CHAPTER 5

- conclusion

CONCLUSION

After analyzing the result reliability improvement is very important in distribution systems also DG significance should be considered. Finally concluded with a mathematical model without and with presence of DG in a radial network. Different types of reliability indices are computed and graphs are plotted. The clear conclusion is the in the presence of DG in the net -work reduces the R Index, Hence the reliability of the system is improved.

The stuffs like SAIFI, SAIDI CAIDI, and AENS etc. are known as Reliability indices, measures the reliability of a system.

From the results the AENS is decreased that signifies the average energy supplied to the customers increased.

BIBLIOGRAPHY

[1]. R. Billinton, *Reliability Evaluation of Engineering Systems*', Plenum Press, New York, 1996.
[2]. Reliability evaluation and enhancement of distribution systems in the presence of distributed generation based on standby mode Electrical Power and Energy Systems 43 (2012) 607–616.
[3]. Rajesh Arya, S.C, Chohbe, L.D Arya, "Reliability evaluation and enhancement of distribution systems in the presence of distributed generation based on standby mode," Electrical power and energy systems, Vol.43, pp. 607-616, 2012.
[4] Distributed Generation Planning and evaluation H.Lee Willis Wal.CRC Press
[5] P. P Barker. and R. W. De Mello, "Determining the impact of distributed generation on power systems: Part 1- Radial distribution systems," IEEE Power technology, Inc, Vol. 3, pp. 1645–1656, 2000.
[6] R. E. Brown and L. A. A. Freeman, "Analyzing the reliability impact of distributed generation," IEEE, Power Engineering Society. Summer Meeting, Vol. 2, pp. 1013–1018, 2001.
[7] R. A. Jabr and B. C. Pal, "Ordinal optimization approach for locating and sizing of distributed generation," IET Generation, Transmission & Distribution, Vol. 3, pp. 713–723, 2009
[8] L. Wang and C. Singh, "Reliability constrained optimum placement of reclosers and distributed generators in distribution networks using an ant colony system algorithm," IEEE Transaction on systems and Mantainance, Vol. 38, pp. 757–764, 2008
[9] D. Karaboga, and B. Basturk, "On the performance of artificial bee colony (ABC) algorithm," Elsevier Applied Soft Computing, Vol. 8, pp.687–697, 2007.
[10] S Hemamalini and Sishaj P Simon., "Economic load dispatch with valve-point effect using artificial bee colony algorithm," xxxii national systems conference, NSC 2008, pp.17-19, 2008.
[11] M.Hlatshwayo, S.Chowdhury, S.P.Chowdhury, K.O.Awodele Reliability Enhancement of Radial Distribution Systems with DG Penetration UPEC2010 Prague, Czech Republic 31st Aug - 3rd Sept 2010
[12] R. Billinton and P Weng, *Teaching Distribution System Reliability Evaluation Using Monte Carlo Simulation*, University of Saskatchewan, Canada, June 2008.
[13] A.C. Nōto and M.G. Dajilva, "Impact of Distributed Generation on Reliability Evaluation of Radial Distribution Systems under Network Constraints", *Proc. of 9th International Conference on Probalistic Methods Applied to Power Systems*, June 11-15, 2006
[14] R. Billinton and S. Jonnavithula, "A Test System for Teaching Overall Reliability Assessment", *IEEE Transactions on Power Systems*, Vol. 11, No. 4, November 1996.
[15] Consortium on Energy Restructuring, Virginia Tech 2007. Distributed Generation Education Modules. Available: http: //www.dg.history.vt.edu/
[16] THOMAS E . MCDERMOTT & ROGER C. DUGAN PQ Reliability and DG I E E E INDUS TR Y AP P L ICAT IONS MAGAZ I NE • S E P T|OCT 2 0 0 3